HD(CP)^2
High definition clouds and precipitation for advancing climate prediction

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

LES-type simulations with the new ICON modelling framework

Daniel Klocke

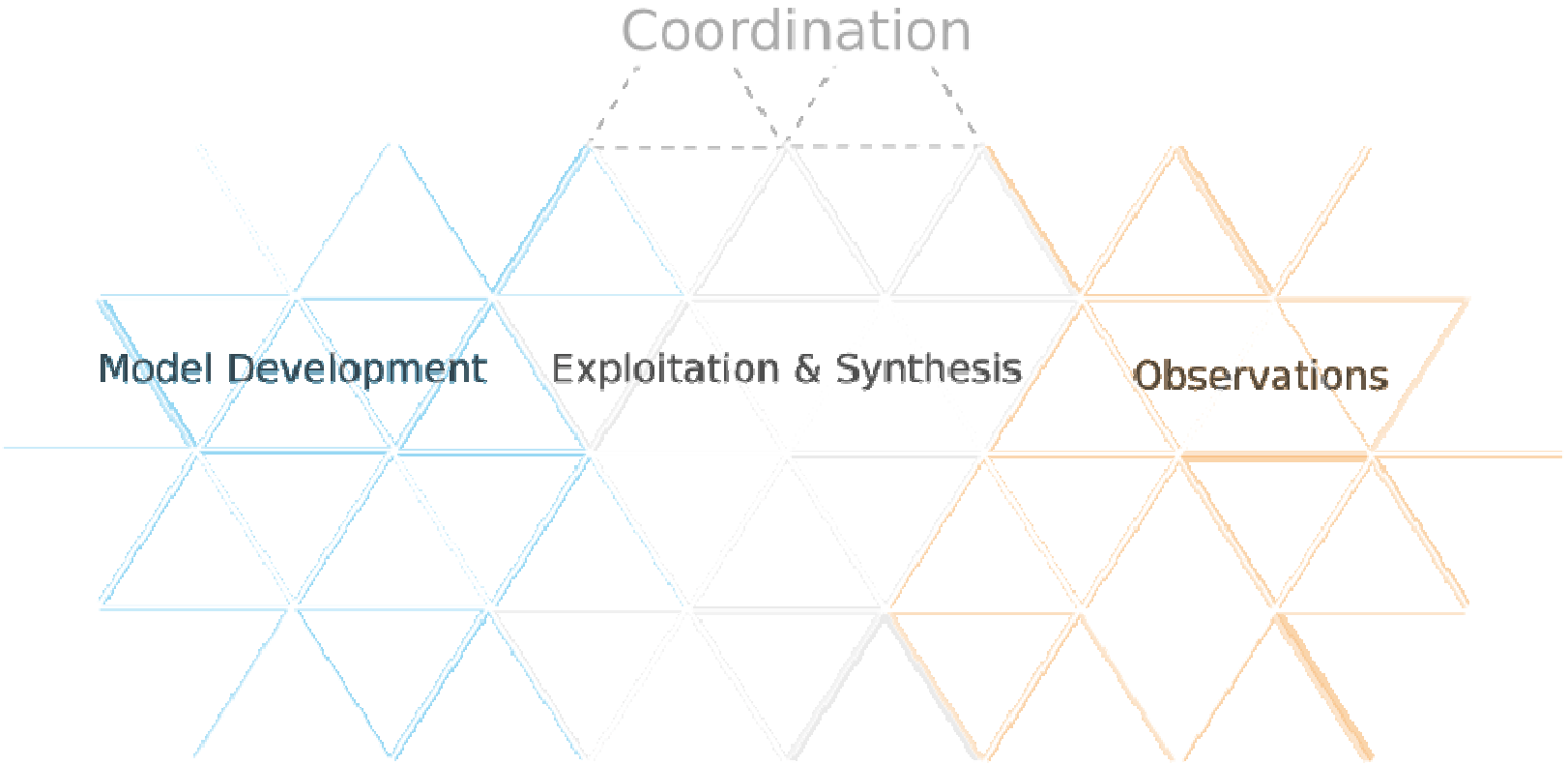
Outline

The HD(CP)² project

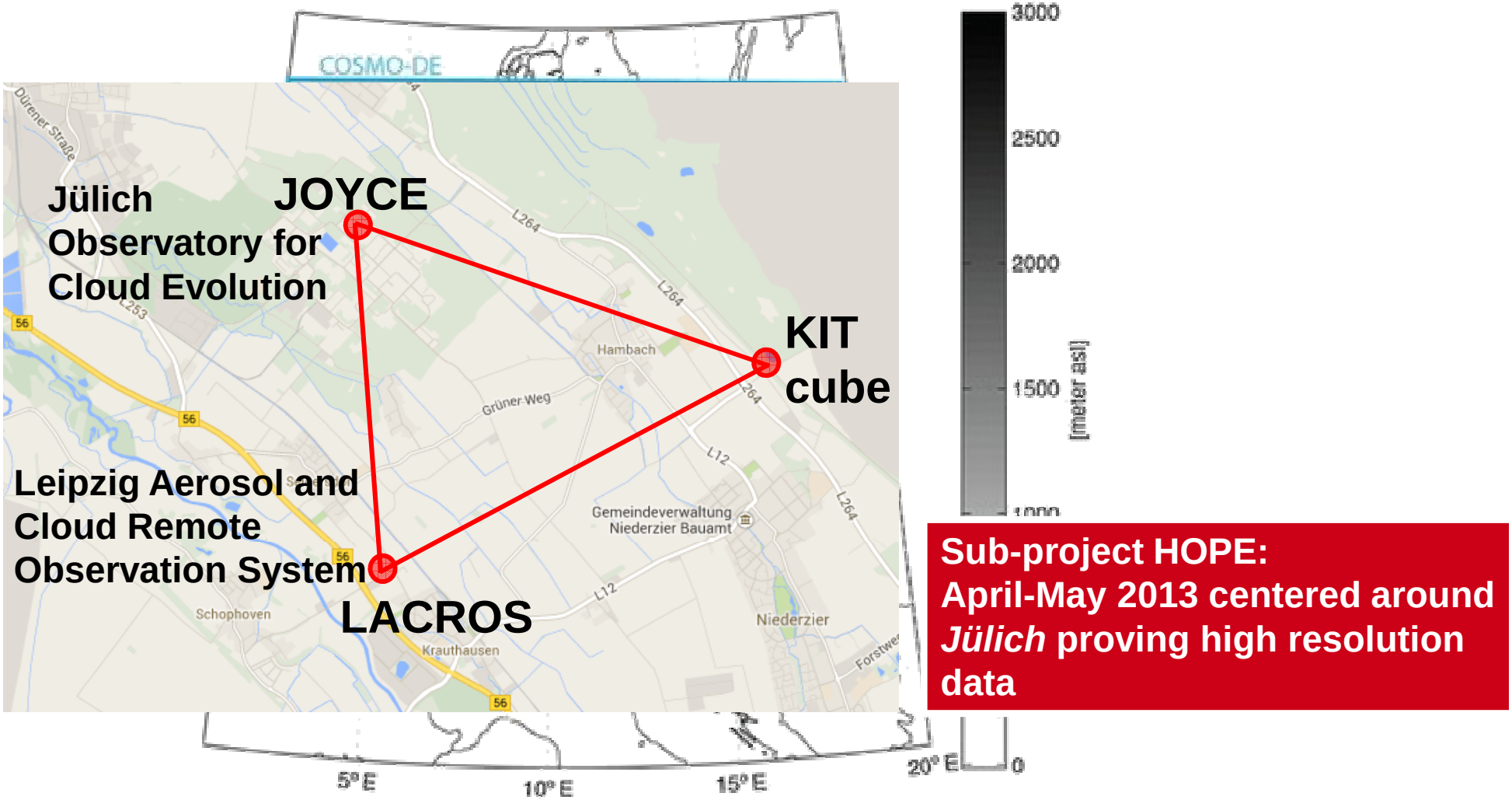
Idealized tests

First results

High Definition Cloud and Precipitation for Climate Prediction



The HD(CP)² Observational Prototype Experiment (HOPE)



Sub-project HOPE:
April-May 2013 centered around *Jülich* proving high resolution data

Getting ICON ready

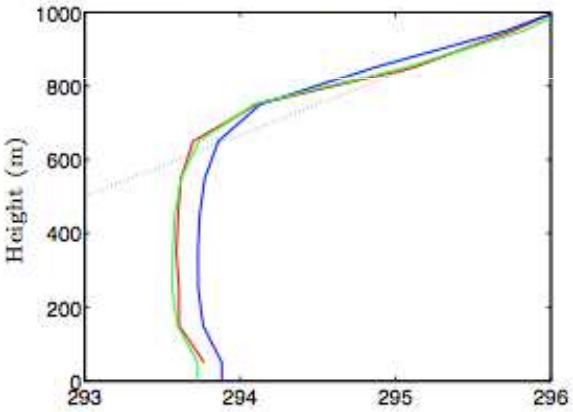
- 3D Smagorinsky turbulence ✔
- Suitable microphysics ✔
- Time dependent lateral BC (async, sync) ✔
- Boundary nudging mechanism ✔
- Managing enormous amount of data (in and out) ✔
- Memory-scaling issue with bigger grids ✔
- Further performance optimization and parallel (I)O ✔

✔ Done ✔ Almost ✔ Not yet

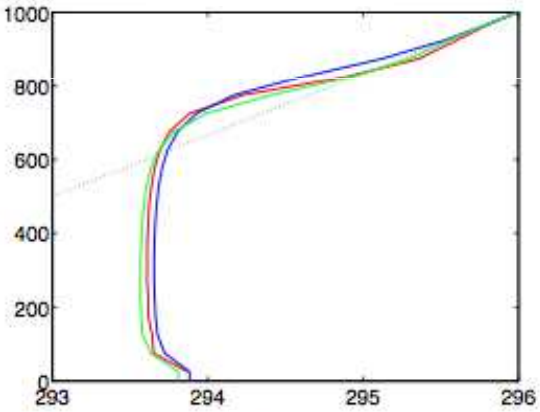
Dry CBL: Grid Convergence

Similar results for other variables and also a cumulus topped boundary layer case

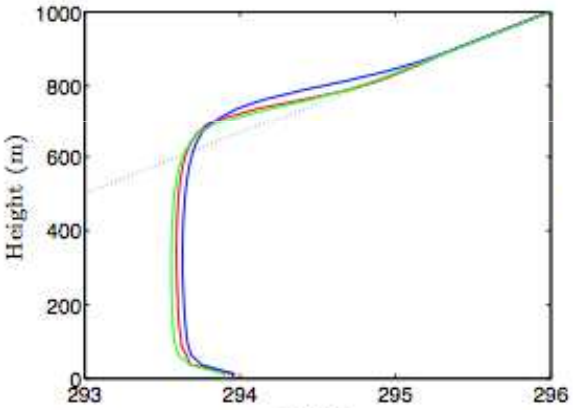
Δx = 100m



Δx = 50m



Δx = 25m



ICON-LES

UCLA-LES

PALM

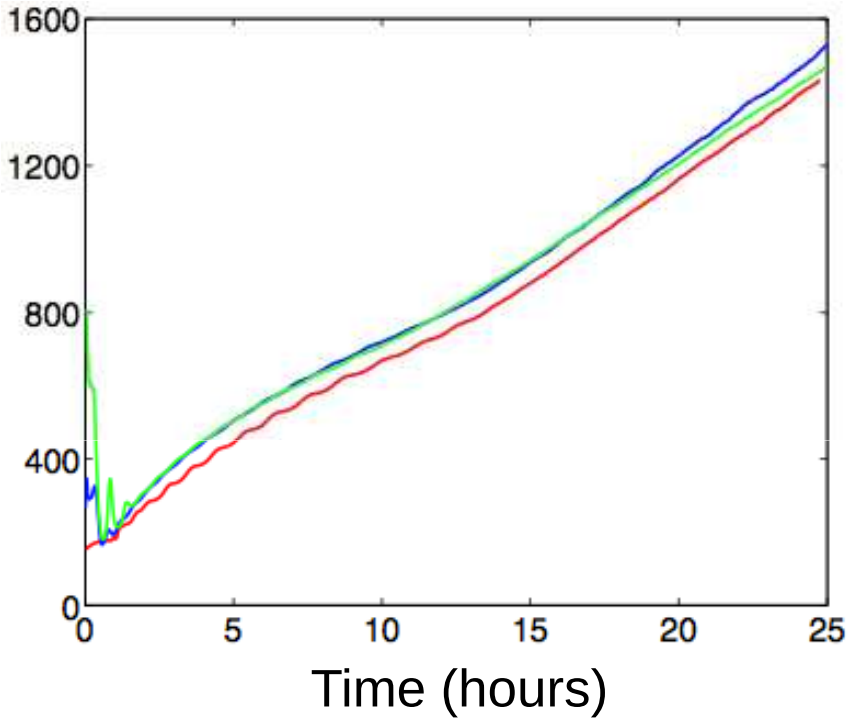
Potential temperature [k]

Double periodic domain
Prescribed surface fluxes

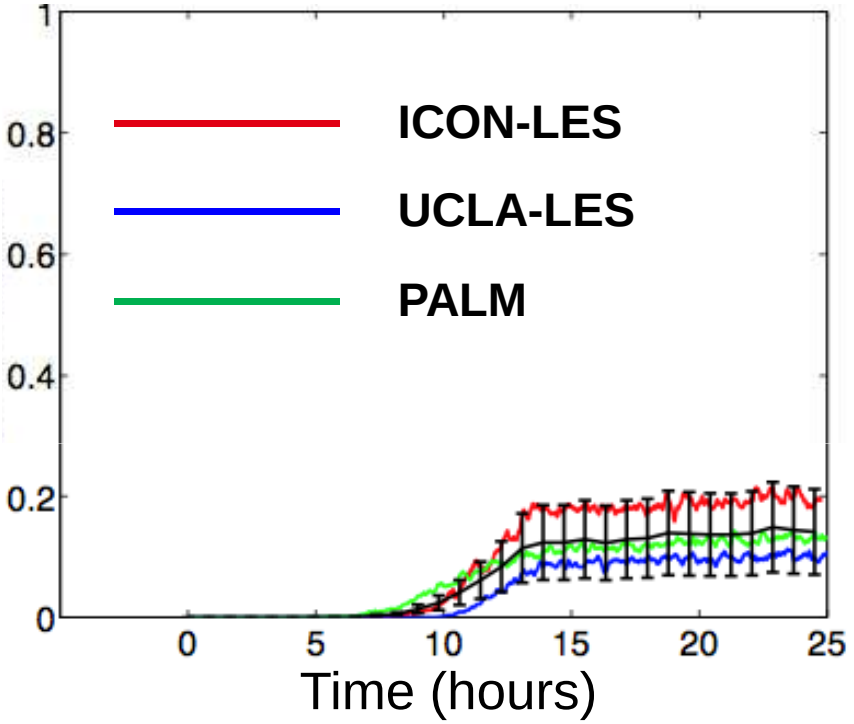
Dipankar et al., in preparation

Cumulus topped BL (Δx = 50m, no precipitation)

Boundary layer height [m]



Fractional cloud cover



Dipankar et al., in preparation

Test experiment setup

- Nested configuration with 3 domains (1250m, 625m and 312m).
- Initialized with COSMO-DE analyses.
- Nudged hourly on the lateral boundaries with COSMO-DE data.
- As NWP setup, but:
  - No parameterized convection.
  - 3D turbulence.
  - 2-Moment micro-physics.
  - Radiation calculated in each grid point.
- External parameter with high input resolution: topography from ASTER (300m), land use data from GLOBCOVER2009 (300m) , soil data from HWSD (1km)

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Model domains

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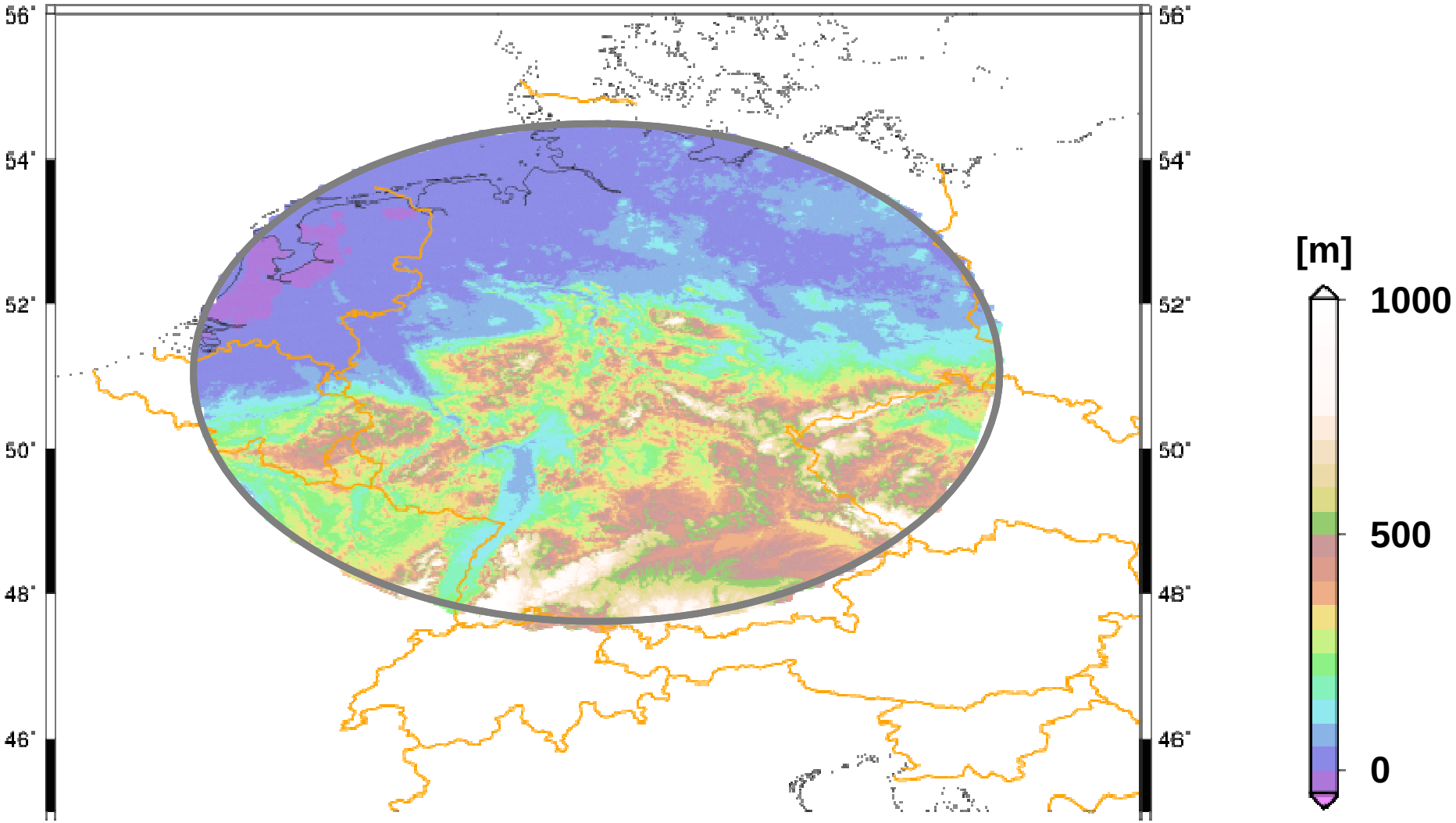
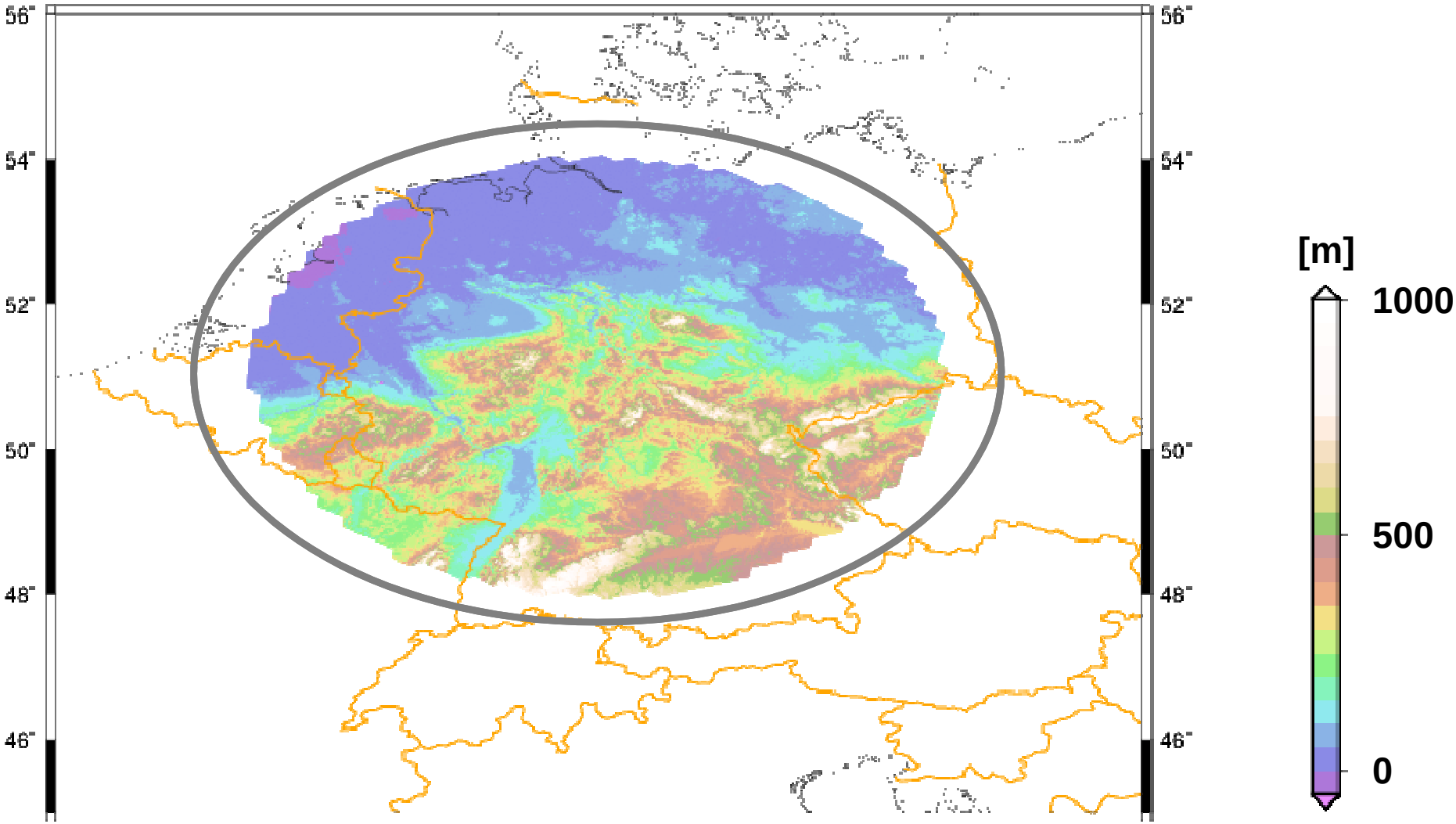
Outer domain: Δx = 1250m, diameter = 776km



Model domains

Refined domain: Δx = 0625m, diameter = 651km

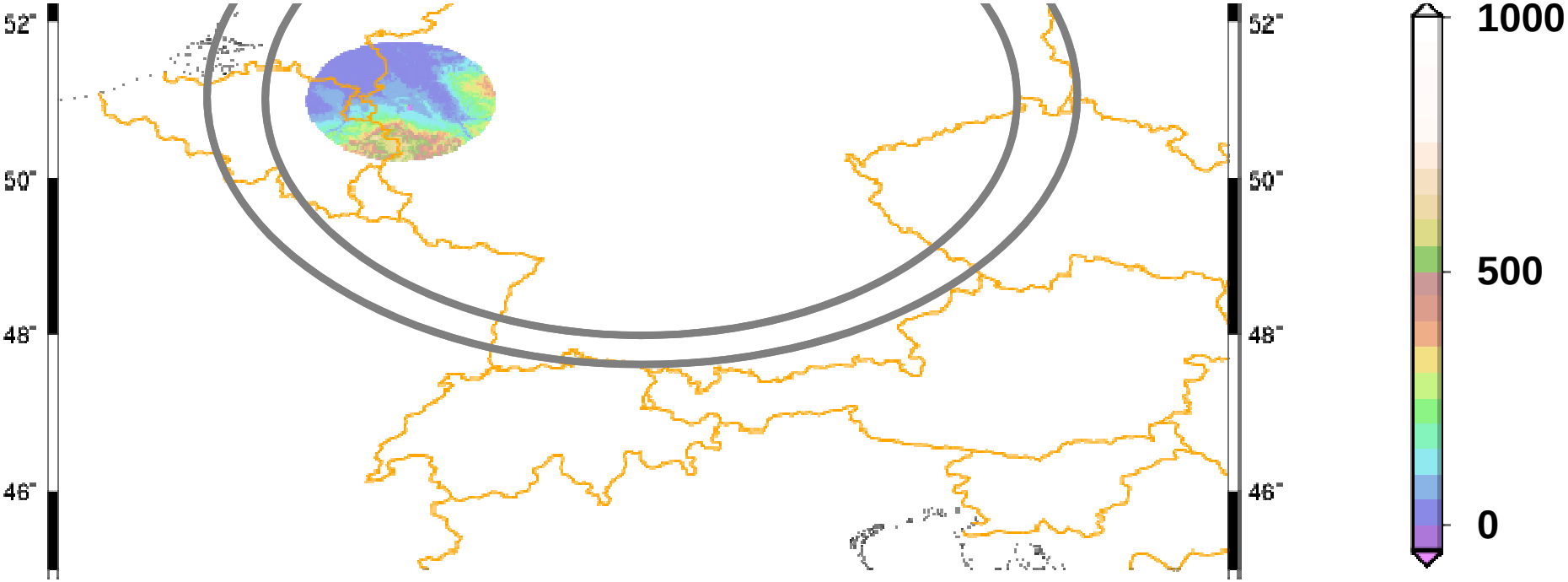


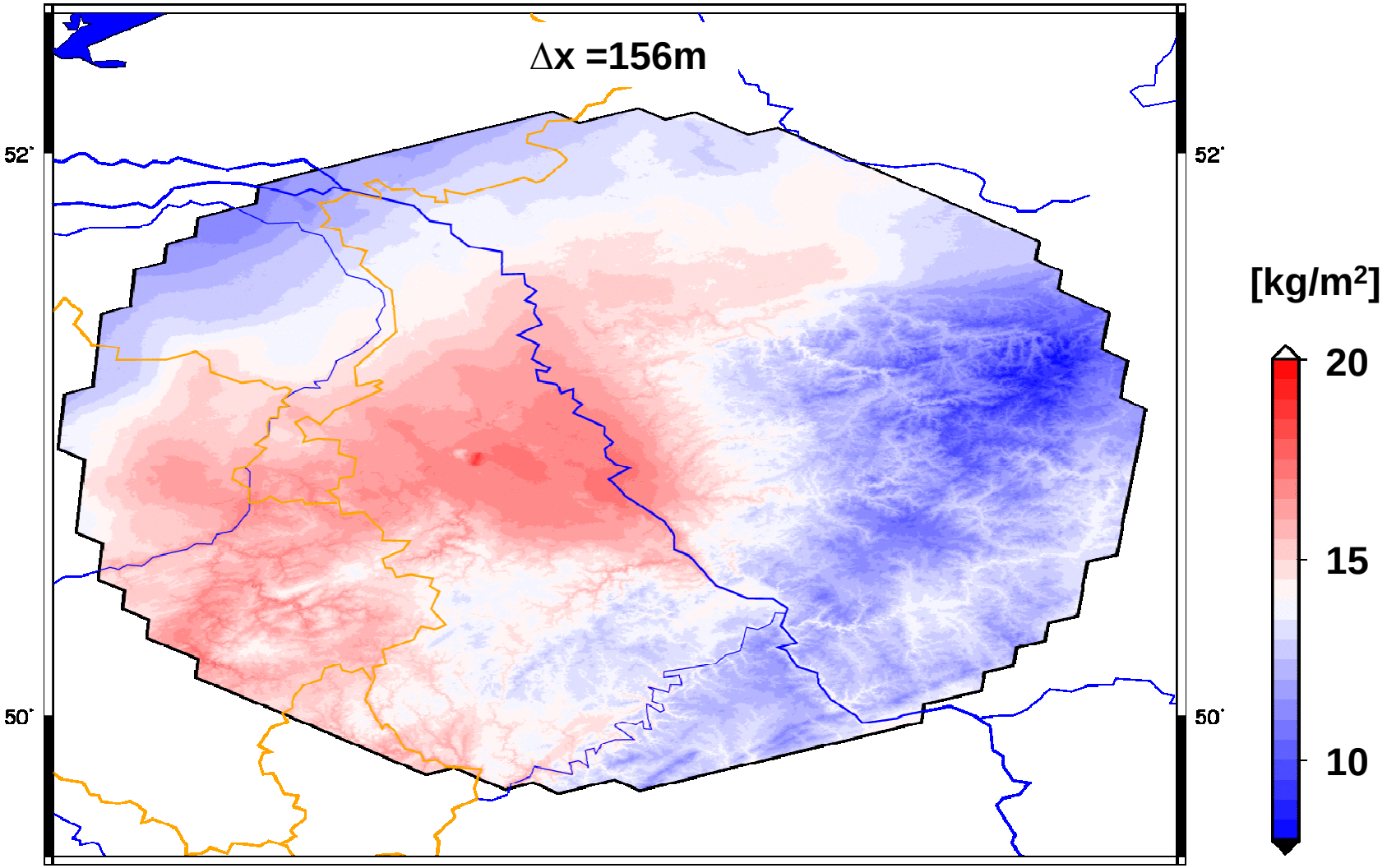
Model domains

LES domain: Δx = 0312m, diameter = 222km

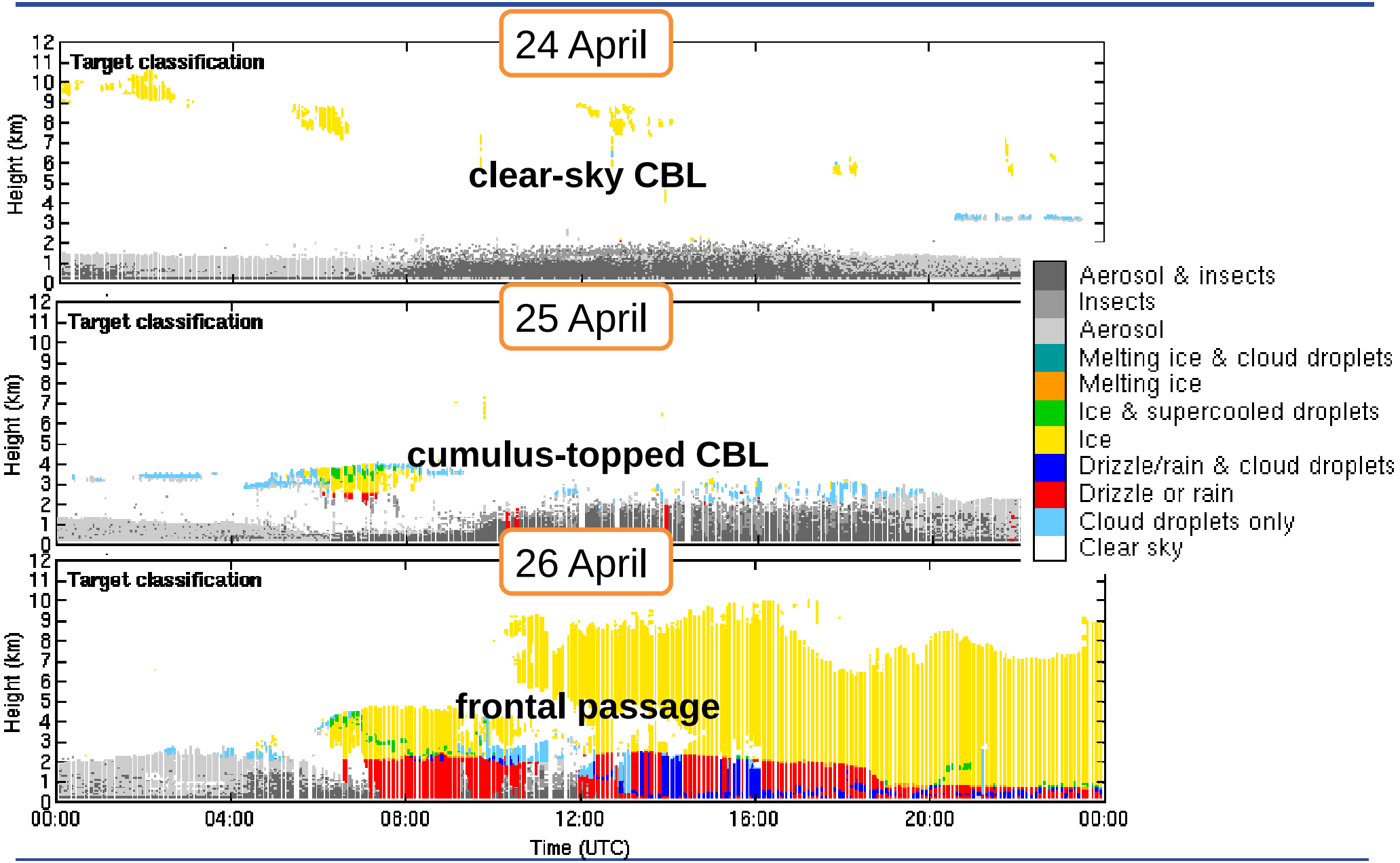
The inner nest of final simulation will cover approximately the middle domain with a horizontal resolution of 150m (~24 Mio. Grid points in the horizontal), with about 200 level in the vertical and the time step will be about a ¼ of a second.

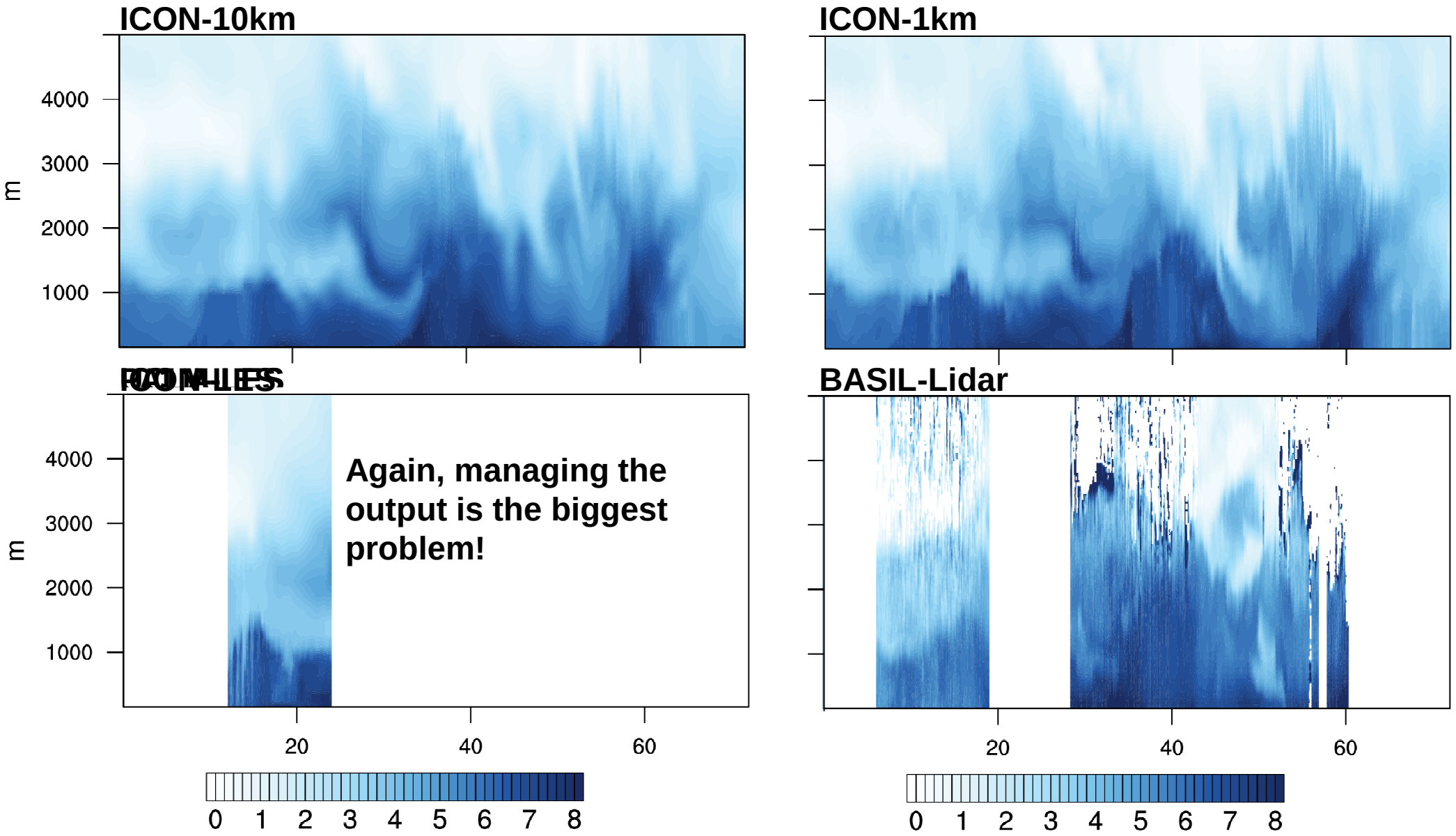
However, the largest problem remains managing the output… The approach will be to have a large set of only diagnostics.



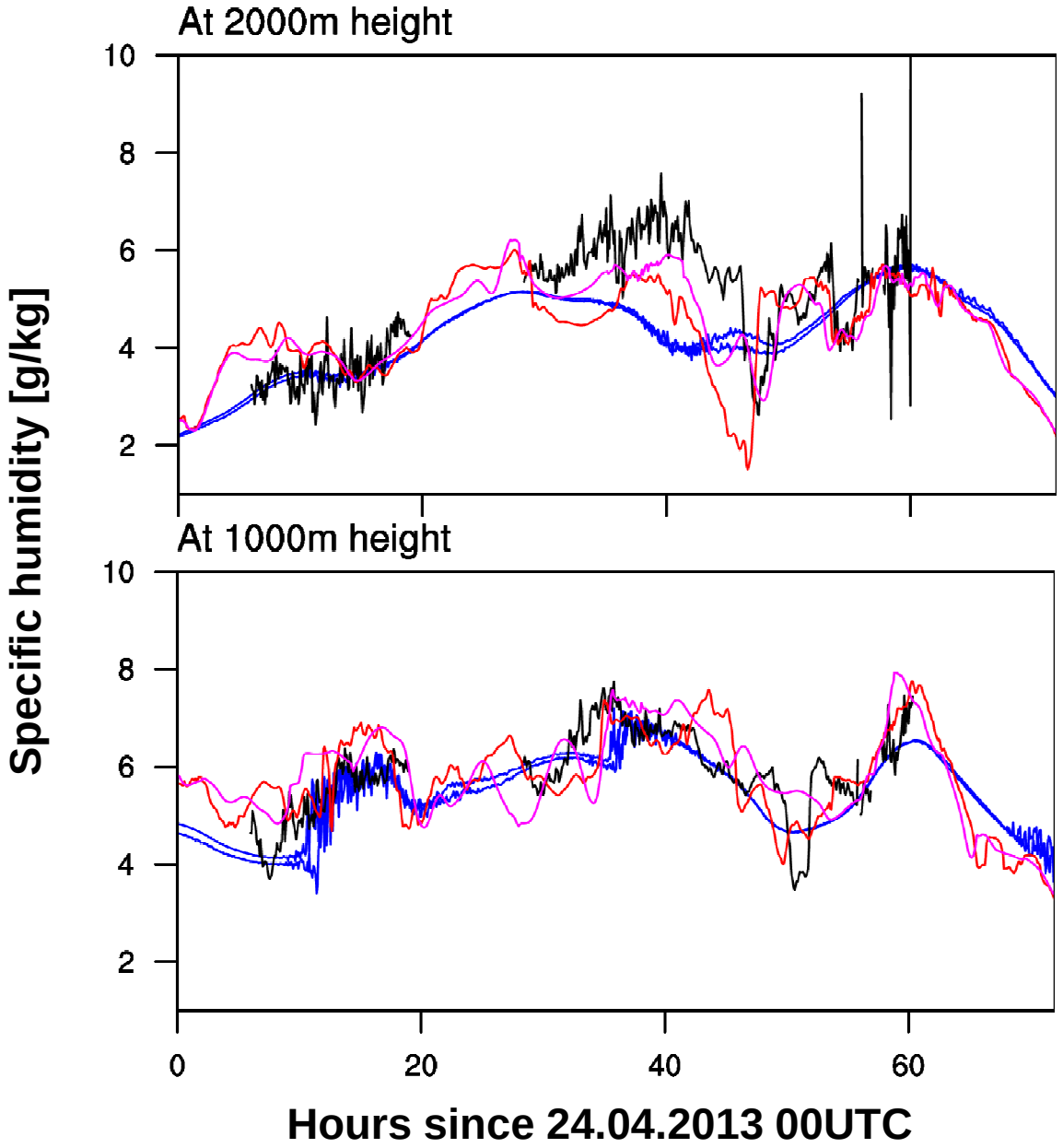


Vertically integrated water vapor 00:00:00

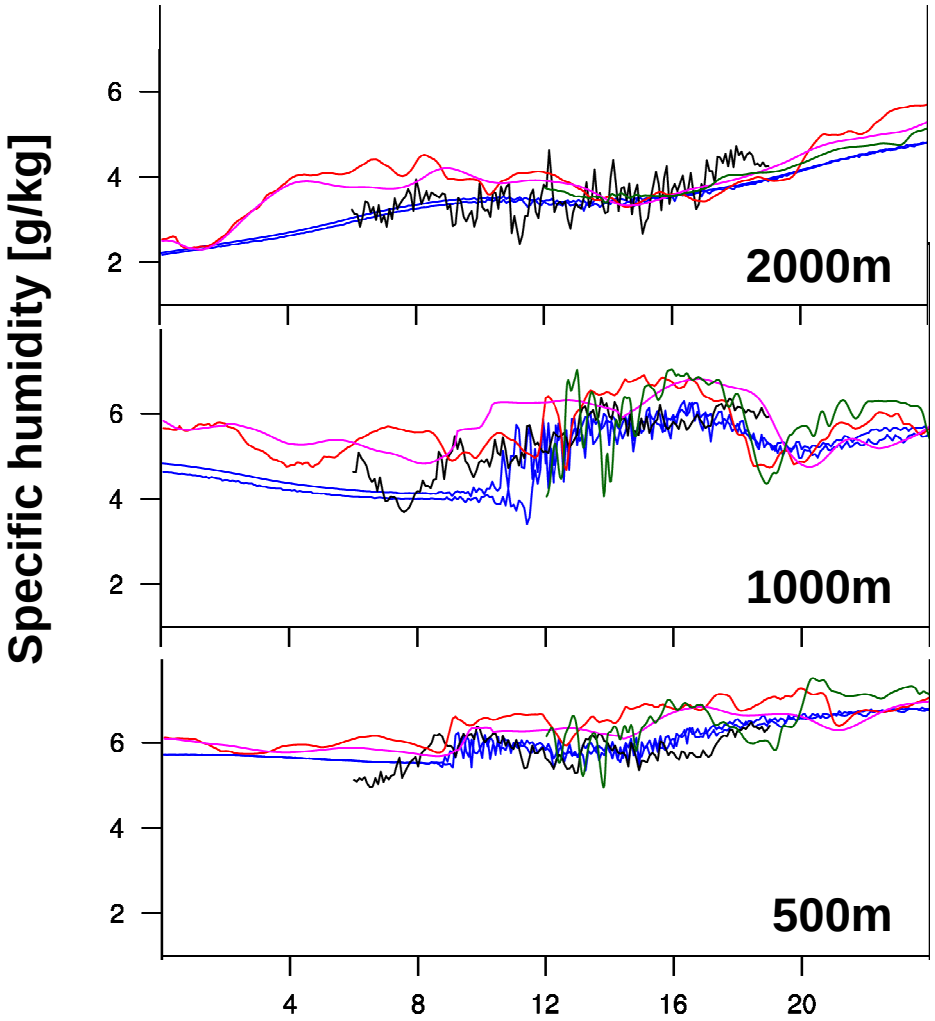

24 April
Target classification
clear-sky CBL
25 April
Target classification
cumulus-topped CBL
26 April
Target classification
frontal passage
Height (km)
Time (UTC)
00:00
04:00
08:00
12:00
16:00
20:00
00:00
Aerosol & insects
Insects
Aerosol
Melting ice & cloud droplets
Melting ice
Ice & supercooled droplets
Ice
Drizzle/rain & cloud droplets
Drizzle or rain
Cloud droplets only
Clear sky



Spec. humidity [g/kg]

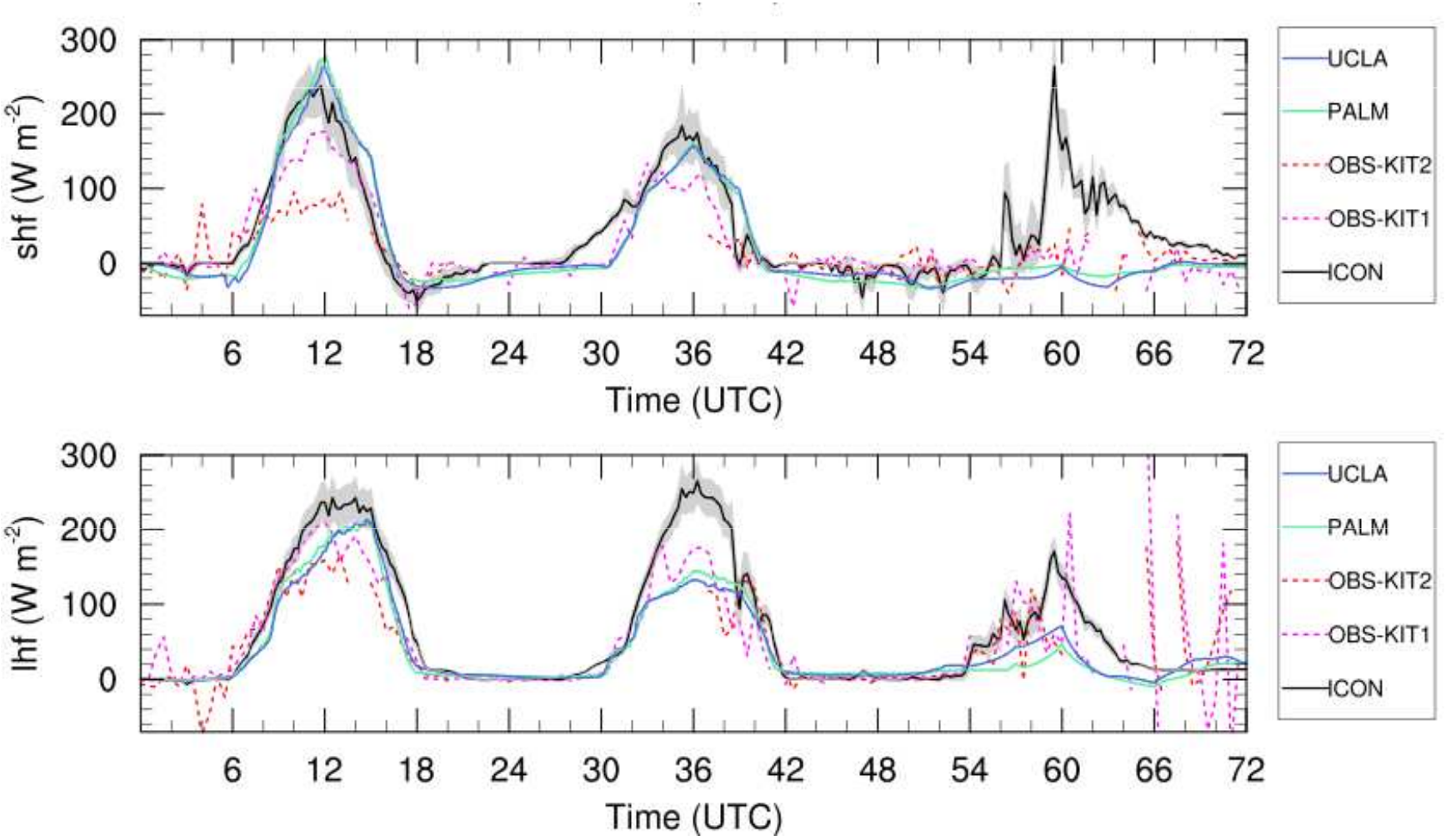


BASIL-Lidar
PALM/UCLA LES
ICON-1km
ICON-10km



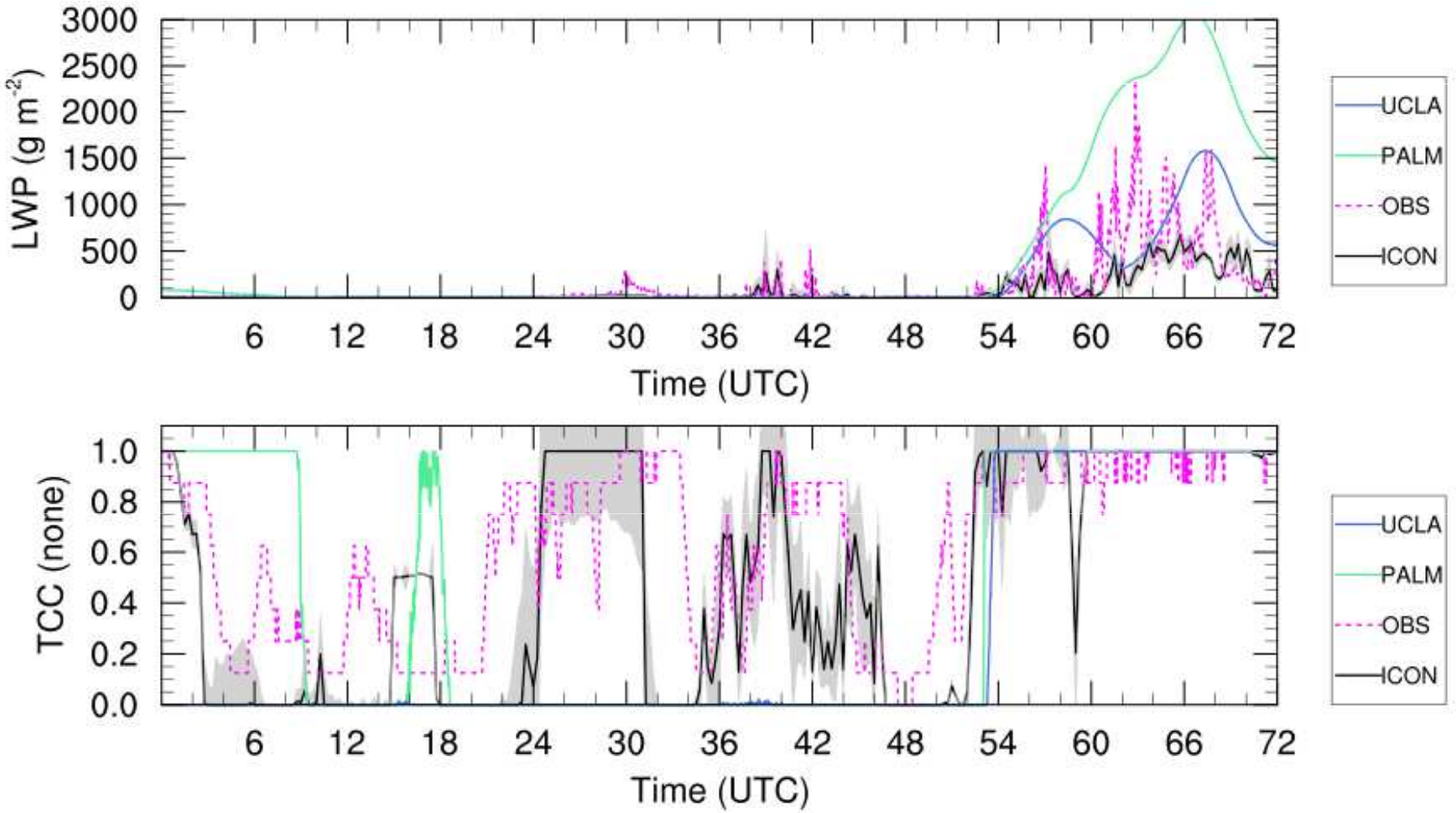
BASIL-Lidar
PALM/UCLA LES
ICON-1km
ICON-10km
ICON-300m (LES)

Surface fluxes: sensible (shf) and latent (lhf) heat flux



higher surface fluxes, observations are not directly at surface.

Liquid water path (LWP) and total cloud cover (TCC)



Good agreement, maybe slightly low LWP and TCC

Conclusions

- ICON-LES exits as a large eddy simulation tool in the global ICON model.
- Despite the limitations (eg. unstructured mesh) that ICON inherits from being a unified modeling system, ICON-LES compares fairly well with the standard LES model for the idealized test cases.
- First analyses indicate that ICON-LES compares well with observations when run in forecast mode.
- Recent scaling results showed that it scales good on ~ 130k cores.
- Much more to be done, but the first results are encouraging.